To: OPP HED Managers[OPP_HED_Managers@epa.gov]; Lowit, Anna[Lowit.Anna@epa.gov]; Kent, Ray[Kent.Ray@epa.gov]; Mendez, Elizabeth[Mendez.Elizabeth@epa.gov]; Dawson, Jeffrey[Dawson.Jeff@epa.gov]
From: Miller, David
Sent: Wed 3/19/2014 1:49:28 PM
Subject: FW: The Atlantic ... The Toxins That Threaten Our Brains [Chlorpyrifos, PBDEs, Lead, Mercury, PCBs, Arsenic, Fluoride, Toluene, Manganese, TCE]
The Atlantic. The Toxins That Threaten Our Brains.pdf

FYI - I've just skimmed it, but seems real interesting.

David.

From: Miller, David
Sent: Wednesday, March 19, 2014 9:44 AM
To: OPP HED TEB; OPP HED CEB
Subject: FW: The Atlantic ... The Toxins That Threaten Our Brains [Chlorpyrifos, PBDEs, Lead, Mercury, PCBs, Arsenic, Fluoride, Toluene, Manganese, TCE]

FYI - pdf attached.

From: Hendricks, Kristen
Sent: Wednesday, March 19, 2014 9:27 AM
To: Kovner, Karissa; Corado, Ana; Blunck, Christopher; Ellenberger, Jay; Miller, David; Hrdy, David; Lowit, Anna
Subject: The Atlantic ... The Toxins That Threaten Our Brains [Chlorpyrifos, PBDEs, Lead, Mercury, PCBs, Arsenic, Fluoride, Toluene, Manganese, TCE]

http://www.theatlantic.com/features/archive/2014/03/the-toxins-that-threaten-our-brains/284466/

The Toxins That Threaten Our Brains

Leading scientists recently identified a dozen chemicals as being responsible for widespread behavioral and cognitive problems. But the scope of the chemical dangers in our environment is likely even greater. Why children and the poor are most susceptible to neurotoxic exposure that may be costing the U.S. billions of dollars and immeasurable

peace of mind.

James Hamblin
March 18, 2014

Forty-one million IQ points. That's what Dr. David Bellinger determined Americans have collectively forfeited as a result of exposure to lead, mercury, and organophosphate pesticides. In a 2012 paper published by the National Institutes of Health, Bellinger, a professor of neurology at Harvard Medical School, compared intelligence quotients among children whose mothers had been exposed to these neurotoxins while pregnant to those who had not. Bellinger calculates a total loss of 16.9 million IQ points due to exposure to organophosphates, the most common pesticides used in agriculture.

Last month, more research brought concerns about chemical exposure and brain health to a heightened pitch. Philippe Grandjean, Bellinger's Harvard colleague, and Philip Landrigan, dean for global health at Mount Sinai School of Medicine in Manhattan, announced to some controversy in the pages of a prestigious medical journal that a "silent pandemic" of toxins has been damaging the brains of unborn children. The experts named 12 chemicals--substances found in both the environment and everyday items like furniture and clothing--that they believed to be causing not just lower IQs but ADHD and autism spectrum disorder. Pesticides were among the toxins they identified.

"So you recommend that pregnant women eat organic produce?" I asked Grandjean, a Danish-born researcher who travels around the world studying delayed effects of chemical exposure on children.

"That's what I advise people who ask me, yes. It's the best way of preventing exposure to pesticides." Grandjean estimates that there are about 45 organophosphate pesticides on the market, and "most have the potential to damage a developing nervous system."

Landrigan had issued that same warning, unprompted, when I spoke to him the week before. "I advise pregnant women to try to eat organic because it reduces their exposure by 80 or 90 percent," he told me. "These are the chemicals I really worry about in terms of American kids, the organophosphate pesticides like chlorpyrifos."

For decades, chlorpyrifos, marketed by Dow Chemical beginning in 1965, was the most widely used insect killer in American homes. Then, in 1995, Dow was fined $732,000 by the EPA for concealing more than 200 reports of poisoning related to chlorpyrifos. It paid the fine and, in 2000, withdrew chlorpyrifos from household products. Today, chlorpyrifos is classified as "very highly toxic" to birds and freshwater fish, and "moderately toxic" to mammals, but it is still used widely in agriculture on food and non-food crops, in greenhouses and plant nurseries, on wood products and golf courses.

Landrigan has the credentials of some superhero vigilante Doctor America: a Harvard-educated pediatrician, a decorated retired captain of the U.S. Naval Reserve, and a leading physician-advocate for children's health as it relates to the environment. After September 11, he made news when he testified before Congress in disagreement with the EPA's assessment that asbestos particles stirred into clouds of debris were too small to pose any real threat. Landrigan cited research from mining townships (including Asbestos, Quebec) and argued that even the smallest airborne asbestos fibers could penetrate deeply into a child's lungs.

Chlorpyrifos is just one of 12 toxic chemicals Landrigan and Grandjean say are having grim effects on fetal brain development. Their new study is similar to a review the two researchers published in 2006, in the same journal, identifying six developmental neurotoxins. Only now they describe twice the danger: The number of chemicals that they deemed to be developmental neurotoxins had doubled over the past seven years. Six had become 12. Their sense of urgency now approached panic. "Our very great concern," Grandjean and Landrigan wrote, "is that children worldwide are being exposed to unrecognized toxic chemicals that are silently eroding intelligence, disrupting behaviors, truncating future achievements and damaging societies."

The chemicals they called out as developmental neurotoxins in 2006 were methylmercury, polychlorinated biphenyls, ethanol, lead, arsenic, and toluene. The additional chemicals they've since found to be toxins to the developing brains of fetuses--and I hope you'll trust me that these all are indeed words--are manganese, fluoride, chlorpyrifos, tetrachloroethylene, polybrominated diphenyl ethers, and dichlorodiphenyltrichloroethane.

Grandjean and Landrigan note in their research that rates of diagnosis of autism spectrum disorder and ADHD are increasing, and that neurobehavioral development disorders currently affect 10 to 15 percent of births. They add that "subclinical decrements in brain function"--problems with thinking that aren't quite a diagnosis in themselves--"are even more common than these neurobehavioral development disorders."

In perhaps their most salient paragraph, the researchers say that genetic factors account for no more than 30 to 40 percent of all cases of brain development disorders:

> Thus, non-genetic, environmental exposures are involved in causation, in some cases probably by interacting with genetically inherited predispositions. Strong evidence exists that industrial chemicals widely disseminated in the environment are important contributors to what we have called the global, silent pandemic of neurodevelopmental toxicity.

Silent pandemic. When public health experts use that phrase--a relative and subjective one, to be deployed with discretion--they mean for it to echo.

When their paper went to press in the journal *The Lancet Neurology*, the media responded with understandable alarm:

- "A 'Silent Pandemic' of Toxic Chemicals Is Damaging Our Children's Brains, Experts Claim" - *Minneapolis Post*, 2/17/14
- "Researchers Warn of Chemical Impacts on Children," -*USA Today*, 2/14/14
- "Study Finds Toxic Chemicals Linked to Autism, ADHD" - *Sydney Morning Herald*, 2/16/14

When I first saw these headlines, I was skeptical. It wasn't news that many of the chemicals on this list (arsenic, DDT, lead) are toxic. With each of these substances, the question is just how much exposure does it take to cause real damage. For instance, organophosphates aren't something that anyone would categorically consider safe, in that they are poison. They kill insects by the same mechanism that sarin gas kills people, causing nerves to fire uncontrollably. But like asbestos, they are still legally used in U.S. commerce, with the idea

that small amounts of exposure are safe. The adage "the dose makes the poison" may be the most basic premise of toxicology. And hadn't we already taken care of lead? Didn't we already know that alcohol is bad for fetuses? Wasn't fluoride good for teeth?

I found that the real issue was not this particular group of 12 chemicals. Most of them are already being heavily restricted. This dozen is meant to illuminate something bigger: a broken system that allows industrial chemicals to be used without any significant testing for safety. The greater concern lies in what we're exposed to and don't yet know to be toxic. Federal health officials, prominent academics, and even many leaders in the chemical industry agree that the U.S. chemical safety testing system is in dire need of modernization. Yet parties on various sides cannot agree on the specifics of how to change the system, and two bills to modernize testing requirements are languishing in Congress. Landrigan and Grandjean's real message is big, and it involves billion-dollar corporations and Capitol Hill, but it begins and ends with the human brain in its earliest, most vulnerable stages.

How Toxins Destroy Brains

About a quarter of your body's metabolism goes toward operating and maintaining your brain. In order to process even basic information, billions of chemical signals are constantly being carried between neurons. The undertaking is so onerous that even though your brain is not moving (like, say, the powerful muscles in your legs), it uses around 10 times more calories per pound than the rest of you.

Most of that industrious brain and its 86 billion neurons were created in a matter of months. During the first few weeks of gestation, when your mother knew you only as morning sickness and you were a layer of cells huddled in one corner of her uterus, those cells lined up, formed a groove, and then closed to form a tube. One end of that tube eventually became your tiny spinal cord. The rest expanded to form the beginnings of your brain.

For a brain to develop properly, neurons must move to precise places in a precise sequence. They do so under the direction of hormones and chemical neurotransmitters like acetylcholine. The process is an intricate, fast-paced dance on a very tiny scale. Each nerve cell is about one hundredth of a millimeter wide, so it has to travel its own width 25,000 times just to move an inch--which some neurons in the cortex must. At any point, that cell can be knocked off course. Some of the neurotoxins Grandjean and Landrigan discuss have the potential to disrupt this journey, in a slight or serious fashion.

By the third trimester, the surface of the brain begins folding itself into wrinkled peaks and valleys, the gyri and sulci that make a brain look like a brain. Specific areas of that cortex learn to process specific aspects of sensation, movement, and thought, and that starts in the uterus. As Grandjean explains this process in his 2013 book *Only One Chance*, "Usage promotes function and structure, as the connectivity of the brain cells is shaped by responses to environmental stimuli." That is, the fetal brain starts having experiences that form the basis for learning and memory. The nature-nurture duality begins at conception.

By age two, almost all of the billions of brain cells that you will ever have are in their places. Except in the hippocampus and one or two other tiny regions, the brain does not grow new brain cells throughout your life. When brain cells die, they are gone. So its initial months of formation, when the brain is most vulnerable, are critical. "During these sensitive life

stages," Grandjean and Landrigan write, exposure "can cause permanent brain injury at low levels that would have little or no adverse effect in an adult."

Federal health officials are aware of this risk. The National Institutes of Health, as Landrigan puts it, "finally woke up in the late 1990s to the fact that children are much more sensitive and vulnerable to chemicals than adults are." Over the past decade, the federal government has invested substantially more money in looking at just how pregnant women and children have been affected by industrial chemicals. The EPA has awarded millions of dollars in related research grants, and the NIH started funding a network of what it calls Centers for Children's Environmental Health and Disease Prevention Research. There is one at Mount Sinai and another at Harvard (the respective homes of Landrigan and Grandjean), and there are others at Columbia, UC Berkeley, and elsewhere.

Those centers have established strong research programs called prospective birth-cohort studies. Scientists enroll pregnant female subjects and carefully record objective measures of environmental exposure, using things like blood samples, urine samples, and maybe even dust and air samples from their homes. After the babies are born, the researchers follow up with them at various points in their childhoods. These studies are expensive and take a long time, but they're incomparably good at connecting prenatal exposures with lost IQ points, shortened attention span, or emergence of ADHD.

"That's the big breakthrough," Landrigan says. "The scientific community has mastered the technique of doing these studies, and they've been running long enough that they're beginning to put out some spectacularly good results." At Columbia, for instance, the children's center is investigating whether children exposed in the womb to BPA and polycyclic aromatic hydrocarbons (PAHs)--byproducts from burning fossil fuels--are more likely to develop learning and behavior disorders than children not exposed. They have also shown that high prenatal exposure to air pollutants like PAHs are associated with attention problems, anxiety, and depression at ages 5 to 7 years. It was this center, together with the UC Berkeley and Mount Sinai children's centers, that first identified the detrimental impact of chlorpyrifos on IQ and brain development. The researchers even used MRI testing to show that these chemicals appear to change children's brain structure, causing thinning of the cortex. Other children's centers are looking at the extent to which these and other chemicals--including arsenic from well water, brominated flame retardants, and the anti-corrosion agent manganese--are to blame for a range of possible neurologic disorders.

Impressive as all this research investment is, the larger question remains: Why are we looking at these hazards now--instead of before we introduced these chemicals into the world?

The Insidious Rise of Lead

The problem with toxic substances is that their effects can be insidious. Take the example of lead--a chemical that lingered in gasoline, house paints, and children's toys for decades before scientists realized the true extent of the damage.

Several years ago, a four-year-old boy in Oregon began complaining of stomach pain and vomiting. Doctors reassured his parents that it was likely a viral illness, but his symptoms worsened, and he became completely unable to eat. He also had a badly swollen cheek. The

doctors determined that the boy had bitten himself, so severely that it must have been during a seizure. Blood tests showed that he was anemic, and subsequent tests found that he had extremely high levels of lead (123 micrograms per deciliter of blood).

The doctors began treating the boy with medication to help clear the lead. They also set out to find out where the lead was coming from. An investigation of the boy's home, which was built in the 1990s, found no lead paint. Despite treatment, though, the boy's lead tests remained abnormally high. So the doctors did an x-ray.

Inside the boy's stomach was a one-inch metal medallion, which appeared bright white on the x-ray image. His parents recognized it as a toy necklace they had purchased from a vending machine approximately three weeks earlier. The state environmental quality lab later found that the medallion contained 38.8 percent lead. The manufacturer later did a voluntary recall of 1.4 million of the metal toy necklaces.

By that time, manufacturers had been using the toxic substance for centuries, despite clearly dangerous effects. In 1786, Benjamin Franklin wrote to a friend about the first time he heard of lead poisoning. When he was a boy, he recounted, there had been "a complaint from North Carolina against New England Rum, that it poisoned their people, giving them the dry bellyache, with a loss of the use of their limbs. The distilleries being examined on the occasion, it was found that several of them used leaden still-heads and worms, and the physicians were of the opinion that the mischief was occasioned by that use of lead." Franklin went on to describe his observations of similar symptoms in patients at a Paris hospital. When he inquired about their occupations, he discovered that these men were plumbers, glaziers, and painters.

In 1921, General Motors began adding tetraethyl lead to gasoline. Lead gave gasoline a higher octane rating, which meant it could handle more compression without combusting. In practical terms, that meant more powerful engines, faster warplanes, and better industrial transport. The Ethyl Corporation that produced leaded gasoline was a joint venture between GM, Standard Oil, and DuPont. One of its executives, Frank Howard, called leaded gasoline "an apparent gift of God," even as the plant where tetraethyl lead was synthesized became known as "the Houses of Butterflies," because it was not uncommon for workers to experience hallucinations of insects on their skin.

Americans in the 1950s and '60s were still widely exposed to unregulated leaded gasoline and paint, as well as piping, batteries, cosmetics, ceramics, and glass. Around that time, studies began to reveal the widespread existence of "subclinical" lead poisoning--damage that was not severe enough to meet diagnostic criteria for a neurologic disease, but would prevent the child from ever achieving optimal intellectual functioning. By 1969, microbiologist and Pulitzer-Prize-winning writer René Dubos said that the problem of lead exposure was "so well-defined, so neatly packaged, with both causes and cures known, that if we don't eliminate this social crime, our society deserves all the disasters that have been forecast for it."

By the mid 1970s, the average U.S. preschool child had 15 micrograms of lead per deciliter of blood. Eighty-eight percent of children had a level exceeding 10 μg/dL--which is twice what the CDC currently considers toxic. Among poor black children, the average level was markedly higher: 23 μg/dL.

Instead of making sweeping policy changes, experts largely accused low-income parents--especially mothers--of inadequate supervision and fostering pathological behaviors that led children to eat paint. With parental ineptitude to blame, and poor, minority children bearing the brunt of the problem, a systematic approach to eliminating lead was a low national priority. Bellinger recounted this in the *Journal of Clinical Investigation*, writing that children were essentially sentinels, used to identify the presence of lead hazards. "As long as the ranks of the lead poisoned consisted primarily of the children of politically and economically disenfranchised parents," he wrote, "it was hard to interest politicians in the problem. Little political capital could be accumulated by tackling the problem."

Finally in 1975, the EPA required a gradual phasing of lead out of gasoline. Two years later, the Consumer Product Safety Commission said that residential paint could contain no more than 0.06 percent lead.

Meanwhile there is still disagreement as to what constitutes a safe level of lead exposure--and if there even is such a thing. As more and more evidence came out over the years showing that low levels are in fact toxic to developing brains, the CDC incrementally lowered that threshold--from 60 micrograms per deciliter of blood in 1970 to 40 in 1971, 30 in 1975, 25 in 1985, 10 in 1991, and finally to just five in 2012.

By 2009 the average lead concentration in the blood Americans was about 1.2 μg/dL for young children--just 8 percent what it was in 1980. But Bellinger notes that even this relatively low level is still "substantially elevated from an evolutionary perspective"--many times higher than before our ancestors "began to disturb the natural distribution of lead in the earth's crust."

"Are the blood lead levels of contemporary humans generally below the threshold of toxicity?" Bellinger wrote. "Let us hope so, but the conclusion that they are is based more on faith than on evidence."

The Toothless Law and the New Test

It's surprising to learn how little evidence there is for the safety of chemicals all around us, in our walls and furniture, in our water and air. Many consumers assume there is a rigorous testing process before a new chemical is allowed to be a part of a consumer product. Or at least some process.

"We still don't have any kind of decent law on the books that requires that chemicals be tested for safety before they come to market," Landrigan said.

The law we do have is the Toxic Substances Control Act (TSCA, pronounced *toss-ka* among those in the know). Passed in 1976 under President Gerald Ford, it is still today the primary U.S. law regulating chemicals used in everyday products. On its face intended to protect people and the environment from dangerous chemical exposure, it is widely acknowledged to have fallen short of its magnanimous goal. It only requires testing for a small percentage of chemicals, those deemed an "unreasonable risk."

"It's just an obsolete, toothless, broken piece of legislation," said Landrigan. "For example, in the early 1990s, EPA was unable to ban asbestos under TSCA." This was after the National Toxicology Program had classified asbestos as a known cancer-causing agent, and the World Health Organization had called for a global ban. The EPA did briefly succeed in

banning asbestos in the U.S. in 1989, but a court of appeals overturned the ban in 1991. Asbestos is still used in consumer products in the U.S., including building materials like shingles and pipe wrap, and auto parts like brake pads.

Landrigan also calls it “a particularly egregious lapse” that when TSCA was enacted, the 62,000 chemicals already on the market were grandfathered in, such that no toxicity testing was required of them. These chemicals were, as Landrigan puts it, “simply presumed safe” and allowed to remain in commerce until a substantial health concern came to public attention.

In the nearly 40 years since the law's passage, more than 20,000 new chemicals have entered the market. “Only five have been removed,” Landrigan says. He notes that the CDC has picked up measurable levels of hundreds of these chemicals in the blood and urine of “virtually all Americans.” Yet, unlike food and drugs, they enter commerce largely untested.

Landrigan and Grandjean's purpose in declaring a silent pandemic was less about the 12 named substances and more about using them as cautionary tales. They named in their list a few chemicals that still appear be imminent threats, but they also include some that have been highly restricted in their use for a long time. And at least one of them, fluoride, has proven beneficial in small doses.

“Fluoride is very much a two-edged sword,” Landrigan said. “There's no question that, at low doses, it's beneficial.” Flouride has been shown to prevent dental cavities and aid skeletal growth. At higher levels, though, it causes tooth and bone lesions. The epidemiologic studies cited by Grandjean and Landrigan, which came from China, imply that high fluoride exposure has negative effects on brain growth.

He's more concerned about flame-retardants--a group of compounds known as polybrominated diphenyl ethers (PBDEs). These chemicals came into vogue after their predecessors, called PCBs (polychlorinated biphenyl ethers), were banned in 1979. By the time it became clear that PCBs caused cancer--and a variety of other adverse health effects on the immune, reproductive, nervous, and endocrine systems--they'd been put into hundreds of industrial and commercial uses like plastics and rubber products. So manufacturers switched to PBDEs and advertised PCB-free products, assuming--or, at least, implying--that PBDEs wouldn't cause problems of their own.

“California, at the urging of the chemical industry several years ago, put the highest standard in the world on the levels of PBDEs that needed to be included in them,” Landrigan explained. “The result is that people in California have the highest levels of brominated flame retardants in their bodies.”

The state finally banned PDBEs in 2006, after studies from Columbia showed high quantities of the compound in women's breast milk and linked it to IQ losses and shortening of attention span. Between 2008 and 2012, PDBE levels in the blood of California residents decreased by two-thirds.

Landrigan and Grandjean argue that stronger chemical safety legislation could have made all of this back-peddling damage control unnecessary. They don't expect every chemical to go through long-term, randomized control studies prior to its release. Rather, they want to see industrial chemicals screened through a simple cell-based test. If that test were to come out positive--if the cells in the petri dish showed any kind of toxic reaction--then the

chemical would be tested further.

A next step from there might be an animal testing model. The drawbacks there, Grandjean told me, are that "those programs are expensive, they take time, you have to kill hundreds and thousands of mice and rats." However, he adds, "if a company has developed a very useful substance, and it turns out to be toxic to nerve cells in petri dishes, then maybe animal testing is the next step."

"I don't think that that should necessarily be a requirement," Grandjean said. "But I can see if a company has developed a very useful substance, and it turns out to be toxic to nerve cells in petri dishes, then maybe that is the next step."

Landrigan and Grandjean both mentioned something they called Tox21, the Toxicology in the Twenty-First Century program program, which is laying groundwork for a new kind of accelerated, large-scale testing. "TSCA reform really falls under EPA's jurisdiction," Landrigan said. "At the NIH and National Institute of Environmental Health Sciences, though, that's where the latest research on this is."

"Are the exposure levels in China comparable to what we have in our drinking water and toothpaste?" I asked.

"No, they're probably higher," Landrigan said. "In some places in China, there are naturally high levels of fluoride in the groundwater, which picks it up because it's water-soluble."

"So your advice isn't to take it out of our toothpaste?"

"Not at all," Landrigan said. "I think it's very good to have in toothpaste."

When I heard that this Tox21 program is teaching a very large yellow robot to do large-scale rapid chemical testing, I had to learn more. Dr. Linda Birnbaum is the director of the National Institute of Environmental Health Sciences and the National Toxicology Program in North Carolina's Research Triangle. Birnbaum oversees federal funding for research to discover how the environment influences health and disease, including Tox21.

"If you want to do the full battery of current tests that we have on a chemical, you're looking at least five years and about $5 million," Birnbaum told me. "We're not going to be able to do that on large numbers of chemicals." The robot is being trained to scan thousands of chemicals at a time and recognize threats inexpensively and quickly--before people get sick. It's also using alternative testing models--looking at not just isolated cells, but also simple organisms like the roundworm *C. elegans* or zebrafish--to answer certain basic questions.

Unlike food and drugs, chemicals enter commerce largely untested.

Tox21 is an effort to hone technology that can effectively do rapid screening--not of one or 10 or 20 chemicals, but of thousands at a time, recognizing threats without spending $5 million per chemical, and doing so quickly, before they make people sick or impaired. It's also using alternative testing models--not just in isolated cells, but in simple organisms like the roundworm *C. elegans* or zebrafish--to answer certain basic questions.

The program is also looking at how a single chemical might affect a wide range of people. "We're looking at 1,000 different human genomes from nine different ethnic groups on five continents," Birnbaum told me.

Like Landrigan, Birnbaum raised the specter of the tens of thousands of chemicals grandfathered in 1976 that underwent no testing, as well as the commonly cited data that less than 20 percent of the 80,000 chemicals in commerce have had any testing at all. She spoke wistfully of the European Union's chemical testing protocol, a model Grandjean had told me was "very reasonable." It's called REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals), and it involves a tiered approach to regulation: If a compound is produced in small amounts, only some cursory information is required. If greater amounts are produced or imported, the EU requires more in-depth testing, such as animal experiments and two-generation studies.

"We've learned a heck of a lot in the last 30 to 40 years about the safety of chemicals and what can cause problems," Birnbaum said, "and it would be really nice if our regulations required us to use some of the newer science to answer the questions of safety."

Don't Panic?

"When you use the word *pandemic*, that's a scare word," said Laura Plunkett. "And that's my problem. There's a more responsible way to express it. I understand that they want to bring it to attention, but when you bring it to attention, you can still do it in what I would say is a scientifically defensible manner."

Plunkett has a Ph.D. in pharmacology and toxicology. Reviewing articles written in the wake of the publicity around *The Lancet Neurology* paper, I was struck by the definitive title of her blog post on a site called Science 20: "There Is No Pandemic of Chemicals Causing Brain Disorders in Children." Plunkett has been a diplomat for the American Board of Toxicology since 1984. She taught for a while and did research at NIH, but she is now an independent consultant running her own company, Integrative Biostrategies.

One of her clients is the American Chemistry Council. She also has clients in the food, pesticide, and chemical business--"industry ties," as they say. With that in mind, I sought her out as an established scientist who has worked on the side of the chemical-producing companies. Her blog post about the *Lancet* article was the only response I found telling people not to panic.

"What [Landrigan and Grandjean] are doing with the data is missing the key component, which is the dose," Plunkett explained. "Many of the chemicals they talk about are well established to be neurodevelopmental toxicants in children--but it's all about how much they're exposed to. Just like anything else. If you don't give people enough, or if you don't take enough in your water or food or the air you breathe, you're not going to have an effect."

Plunkett insists that, unlike lead, some of the chemicals on the *Lancet Neurology* list are only developmental toxicants at very high levels--the sort, she says, "that nobody would be exposed to on a daily basis."

Plunkett says she has no problem with a call to ensure that chemical testing is as thorough as possible. "But then to say, and by the way, if you look at the data, 'We've been poisoning people for the last 10 years'? That's a whole other step that isn't supported by the data they point to."

I asked her how concerned American parents should be about certain individual chemicals

on Grandjean and Landrigan's list. “I mean, we knew lead was a problem 30 years ago,” she said, “and that's why we removed it from gasoline, and that's why we don't let it in solder and cans, and we've taken lead-based paint off the market.”

“If you really look at the data on fluoride,” she continued, “trying to link an IQ deficit in a population with that chemical is almost impossible to do. Even though statistically, randomly they may have found a relationship, that doesn't prove anything--it identifies a hazard but doesn't prove there's a cause and effect between the two things.”

What about the chemical that most concerned Landrigan, the pesticide chlorpyrifos?

“No, because the organophosphate pesticides are one of the most highly regulated groups of chemicals that are out there. The EPA regulates those such that if they're used in agriculture, people are exposed to very, very low levels.”

Pesticides are indeed more regulated than other industrial chemicals. Before manufacturers can sell pesticides in the U.S., the EPA must ensure that they meet federal standards to protect human health and the environment. Only then will the EPA grant a "registration" or license that permits a pesticide's distribution, sale, and use. The EPA also sets maximum levels for the residue that remains in or on foods once they're sold.

An EPA spokesperson told me that a company introducing a new pesticide must “demonstrate more than 100 different scientific studies and tests from applicants.” The EPA also said that since 1996's Food Quality Protection Act, it has added “an additional safety factor to account for developmental risks and incomplete data when considering a pesticide's effect on infants and children, and any special sensitivity and exposure to pesticide chemicals that infants and children may have.” Landrigan and Grandjean don't believe that's always sufficient; the dose may make the poison, but not everyone believes the EPA's limits are right for everyone.

When I asked Plunkett whether new industrial chemicals were being screened rigorously enough, even she cited the need to strengthen the Toxic Substances Control Act of 1976. “I'm a very strong proponent of fixing the holes we have,” she said, “and we do have some holes under the old system, under TSCA, and those are what the new improvements are going to take care of. They're going to allow us to look at the chemicals out there we don't have a lot of data on--and really those are the ones I'm more concerned about.”

The High Price of Lost IQ

Everyone I spoke to for this story agreed that TSCA needs to be fixed. But every attempt has met with bitter opposition. All parties want it to happen; they just want it to happen on their own terms. Unless it does, they don't want it to happen at all.

Last May, a bipartisan group of 22 senators, led by Frank Lautenberg and David Vitter, introducing the Chemical Safety Improvement Act of 2013. Lautenberg, then 89 years old, was the last surviving World War II veteran in the Senate and a longtime champion of environmental safety. (Among other things, he wrote the bill that banned smoking on commercial airlines.) A month after he introduced his TSCA reform bill, Lautenberg died of pneumonia.

After Lautenberg's death, Senator Barbara Boxer told reporters the bill “would not have a chance” of passing without major changes. “I will be honest with you,” said Boxer, who

chairs the Committee on Environment and Public Works, "this is the most opposition I've ever seen to any bill introduced in this committee." Some of the resistance came from environmental and health advocates who felt the bill would actually make it harder for states to regulate the chemicals that were grandfathered in by TSCA. Their fears intensified in January, after 10,000 gallons of a coal-processing substance poured into West Virginia's Elk River, contaminating a nearby water treatment plant. (The *Wall Street Journal* reported, "Little is known about the chemical's long-term health effects on people, although it isn't believed to be highly toxic.")

In February, with Lautenberg's bill stalled in the Senate committee, Republican Representative John Shimkus seized the opportunity to introduce another reform option called the Chemicals in Commerce Act. The chemical industry applauded Shimkus' bill--it won support from the American Chemistry Council, American Cleaning Institute, and the Society of Chemical Manufacturers and Affiliates. Earlier this month at the GlobalChem conference in Baltimore, Dow Chemical's Director of Products Sustainability and Compliance Connie Deford said that TCSA reform was in the interests of the chemical sector, acknowledging that consumer confidence in the industry is at an all-time low.

Yet the Chemicals in Commerce Act has provoked strong criticism from groups like the Center for Environmental Health and the Natural Resources Defense Council. A senior scientist with the Environmental Defense Fund called the bill "even more onerous and paralyzing" than the present law, and Representative Henry Waxman, ranking member of the House Energy and Commerce Committee, said the bill "would weaken current law and endanger public health."

I asked the EPA to comment on Landrigan and Grandjean's claim that we are in the midst of a "silent pandemic" and inquired what, if anything, is being done about it. The agency responded by sending me a statement: "EPA has taken action on a number of the chemicals highlighted in this report which have and are resulting in reduced exposures, better understanding, and more informed decisions." The agency included a list of the actions it has already taken to reduce exposure to the chemicals identified in the report. (See sidebar.) And it emphasized a 2012 "Work Plan," which includes plans to assess more than 80 industrial chemicals in the coming years.

When I emailed the statement to Landrigan, he replied, "Many of the items that they list here are things that I helped to put in place." (In 1997, he spent a sabbatical year setting up EPA's Office of Children's Health Protection.) He agreed that the EPA is doing a lot to protect children from environmental threats. "But the problem is that the good people within EPA are absolutely hamstrung by the lack of strong legislation," he wrote. "They can set up research centers to study chemicals and outreach and education programs, but without strong and enforceable chemical safety legislation, they cannot require industry to test new chemicals before they come to market, and they cannot do recalls of bad chemicals that are already on the market."

Meanwhile, researchers like David Bellinger, who calculated IQ losses, are highlighting the financial cost to society of widespread cognitive decline. Economist Elise Gould has calculated that a loss of one IQ point corresponds to a loss of $17,815 in lifetime earnings. Based on that figure, she estimates that for the population that was six years old or younger in 2006, lead exposure will result in a total income loss of between $165 and $233 billion.

The combined current levels of pesticides, mercury, and lead cause IQ losses amounting to around $120 billion annually--or about three percent of the annual budget of the U.S. government.

Low-income families are hit the hardest. No parent can avoid these toxins--they're in our couches and in our air. They can't be sweated out through hot yoga classes or cleansed with a juice fast. But to whatever extent these things *can* be avoided without better regulations, it costs money. Low-income parents might not have access to organic produce or be able to guarantee their children a low-lead household. When it comes to brain development, this puts low-income kids at even greater disadvantages--in their education, in their earnings, in their lifelong health and well-being.

Grandjean compares the problem to climate change. “We don't have the luxury to sit back and wait until science figures out what's really going on, what the mechanisms are, what the doses are, and that sort of thing. We've seen with lead and mercury and other poisons that it takes decades. And during that time we are essentially exposing the next generation to exactly the kind of chemicals that we want to protect them from.”

The EPA Responds

The agency says it has taken the following actions to reduce exposure to the chemicals mentioned in Grandjean and Landrigan's report:

- **Chlorpyrifos:** Banned all uses in and around homes
- **Polybrominated diphenyl ethers:** Reviewing all new uses, following a voluntary phase out by U.S. manufacturers
- **Lead:** Numerous federal regulations over the past few decades, leading to dramatically reduced childhood blood lead levels
- **Methylmercury:** Significant efforts to reduce exposure, including 2011 standards that reduce pollution from coal and oil-fired power plants
- **Polychlorinated biphenyls:** TSCA banned the manufacture and import of PCBs, and EPA is reassessing the largest remaining uses
- **Arsenic:** Banned some types of arsenic, restricted others
- **Fluoride:** Established safe drinking water standards and currently considering other revisions
- **Toluene:** Included in the 2012 Work Plan, with assessment to begin by 2017
- **Manganese:** Included in the 2012 Work Plan, with assessment to begin by 2017
- **Tetrachloroethylene:** Included in the 2012 Work Plan, with assessment to begin by 2017